Incorporating new forest PFTs and drought mortality mechanisms into CLM4.5

Polly Buotte
Department of Forest Ecosystems & Society
Oregon State University

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Forest Mortality, Economics, and Climate (FMEC)

P.I.s: Phil Mote, Bev Law, Andrew Plantinga, Jeff Hicke

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Goal: Evaluate recent and future disturbance, harvest, and climate effects on carbon storage

Methods:

- Run CLM4.5 at 1/24 degree (4km) resolution over the western US
- New PFTs assigned from Ruefenacht et al. (2008) forest type
- New soil data created from SSURGO and STATSGO
- Spin up forced with downscaled and bias corrected CRUNCEP climate, also used for 1900-1978
- 1979-2015 forced with daily data (Abatzoglou, 2012) disaggregated to 3-hrly (bias correction reference data)
- Implement new, or modify existing, code to account for tree mortality from
    - beetles
    - drought
    - fire
- Harvest based on economic conditions

New PFTs

	New PFT Forest Type
0	Non-veg
1	Doug Fir
2	Lodgepole
3	Ponderosa
4	Pinyon/Juniper
5	Eng Spruce/Subalpine Fir
6	5-needle Pine
7	Aspen/Hardwood
8	Oak
9	Hemlock/Cedar/Sitka
10	Western Doug Fir
11	Mixed Fir
12	CA Mixed Conifer
13	Redwood
14	Larch

Parameters:

- SLA, leaf & fine root C:N, leaf longevity, flnr
- values from TERRA_PNW plot data (Berner & Law 2016, Nature Sci Data)

SourceMods:

- Multiple files modified
- Code tested to ensure all PFTs are behaving as trees

Initial Evaluation:

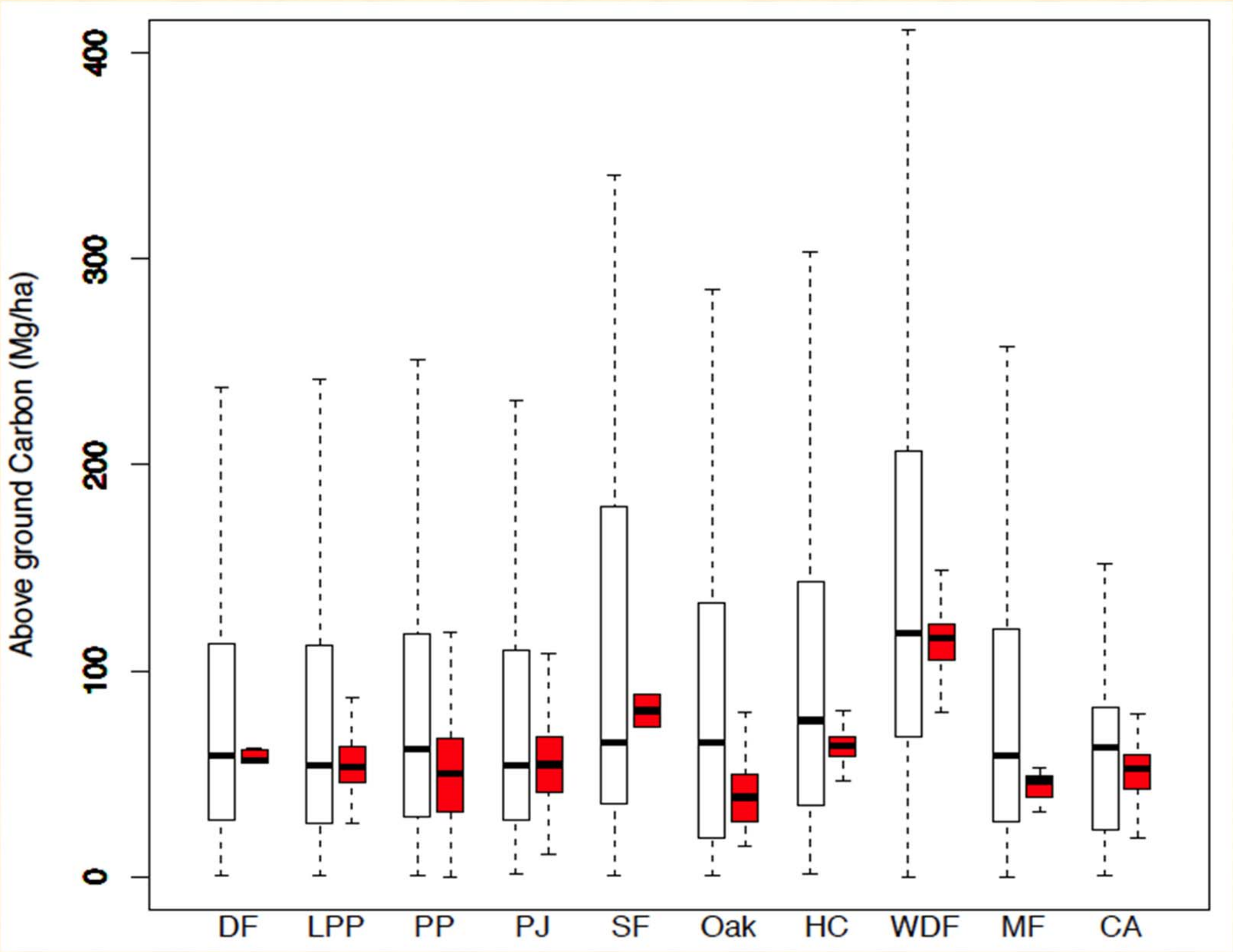
- Runs of 100 grid cells for each PFT
- Compared above ground carbon against Wilson et al. 2013

CLM Biomass Evaluation Over Oregon PFTs

white = FIA, red = CLM

Grid cells with FIA plots
100% focal PFT (CLM and FIA same PFT)

DF = Doug Fir
LPP = Lodgepole
PP = Ponderosa
PJ = Pinyon/Juniper
SF = Spruce/Fir
Oak = Oak
WDF = West slope Doug Fir
MF = Mixed Fir
CA = CA Mixed Conifer

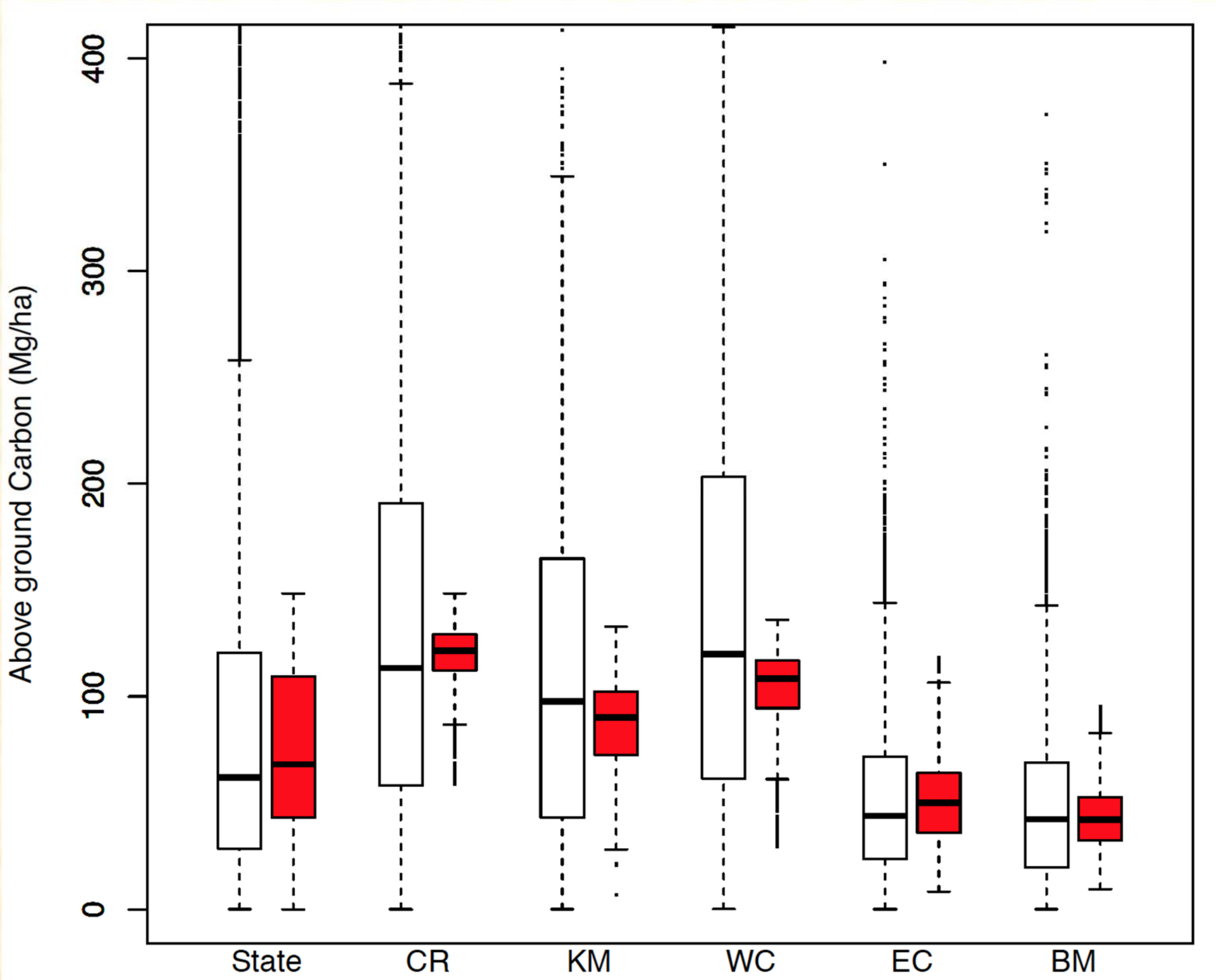


CLM Biomass Evaluation Over Oregon Ecoregions

white = FIA, red = CLM

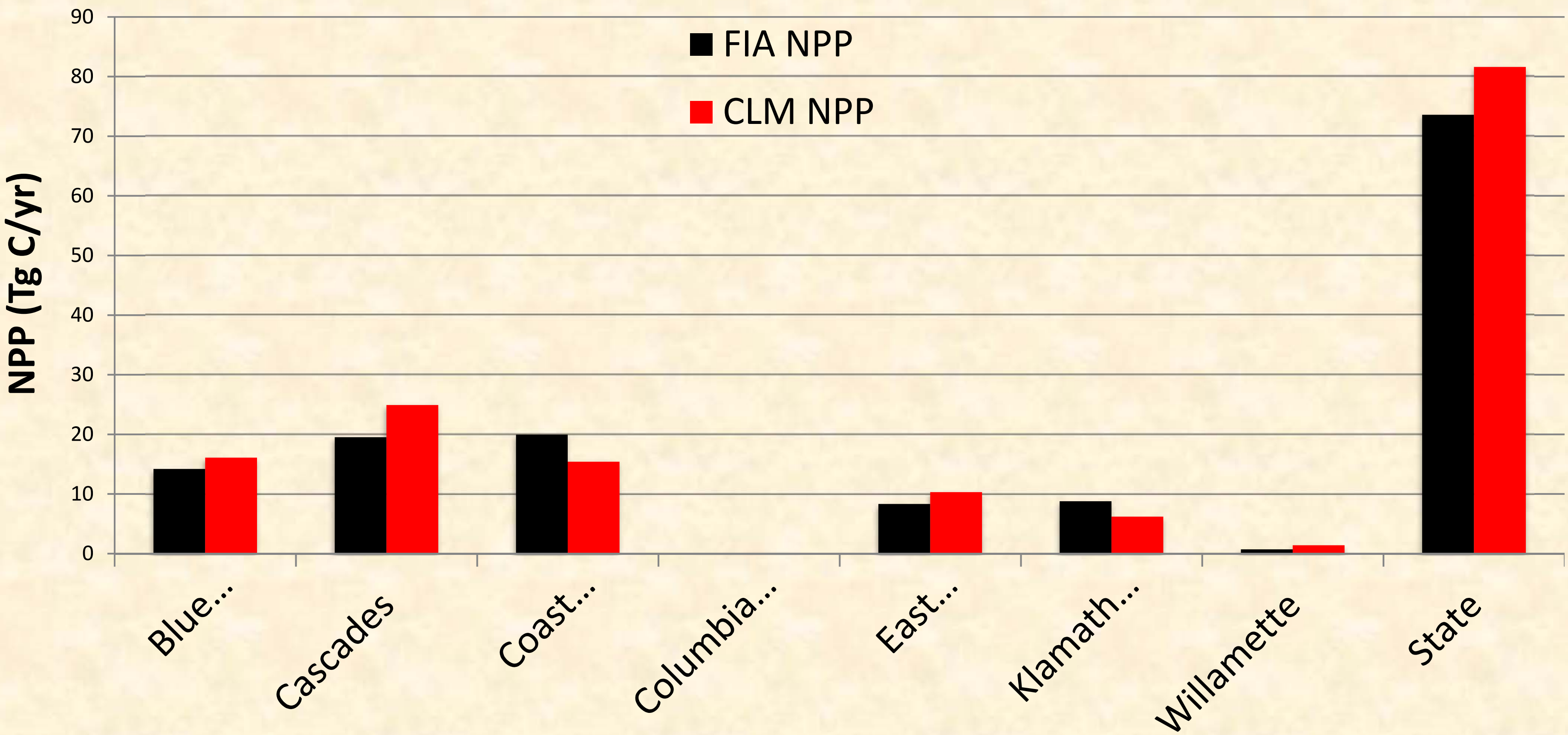
All grid cells with FIA plots

CR = Coast Range
KM = Klamath Mtns
WC = West Cascades
EC = East Cascades
BM = Blue Mtns



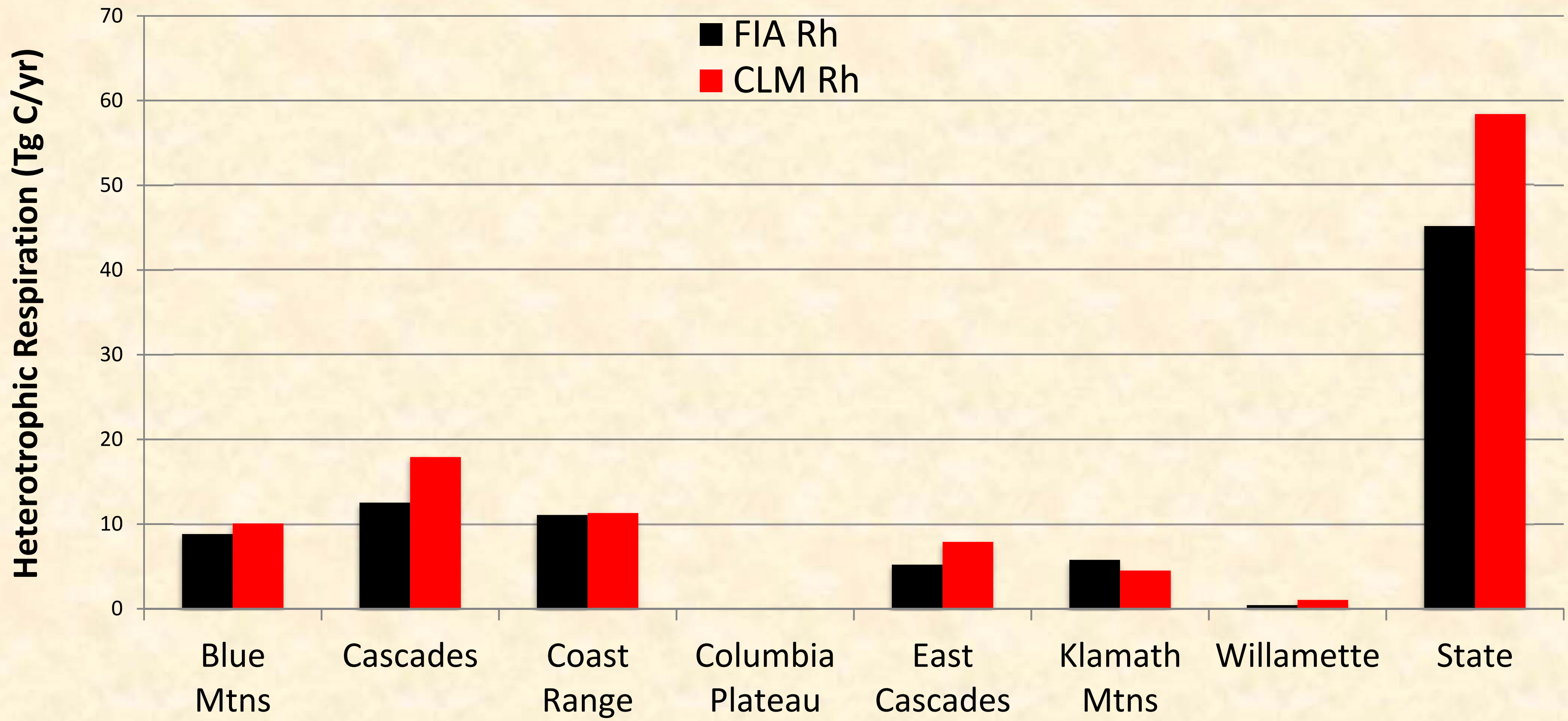
CLM NPP Evaluation Over Oregon

black = FIA, red = CLM



CLM Rh Evaluation Over Oregon

black = FIA, red = CLM



New Drought Mechanisms in CLM4.5

1. Water stress control on stomatal closure and photosynthesis

1. Water stress control on leaf shed

1. Mortality trigger after period of no growth

a work in progress!!

1. Water Stress Control on Photosynthesis

- Scalar based on wilting factor and rooting parameters summed over all soil layers

$$\beta_t = \sum_i w_i r_i$$

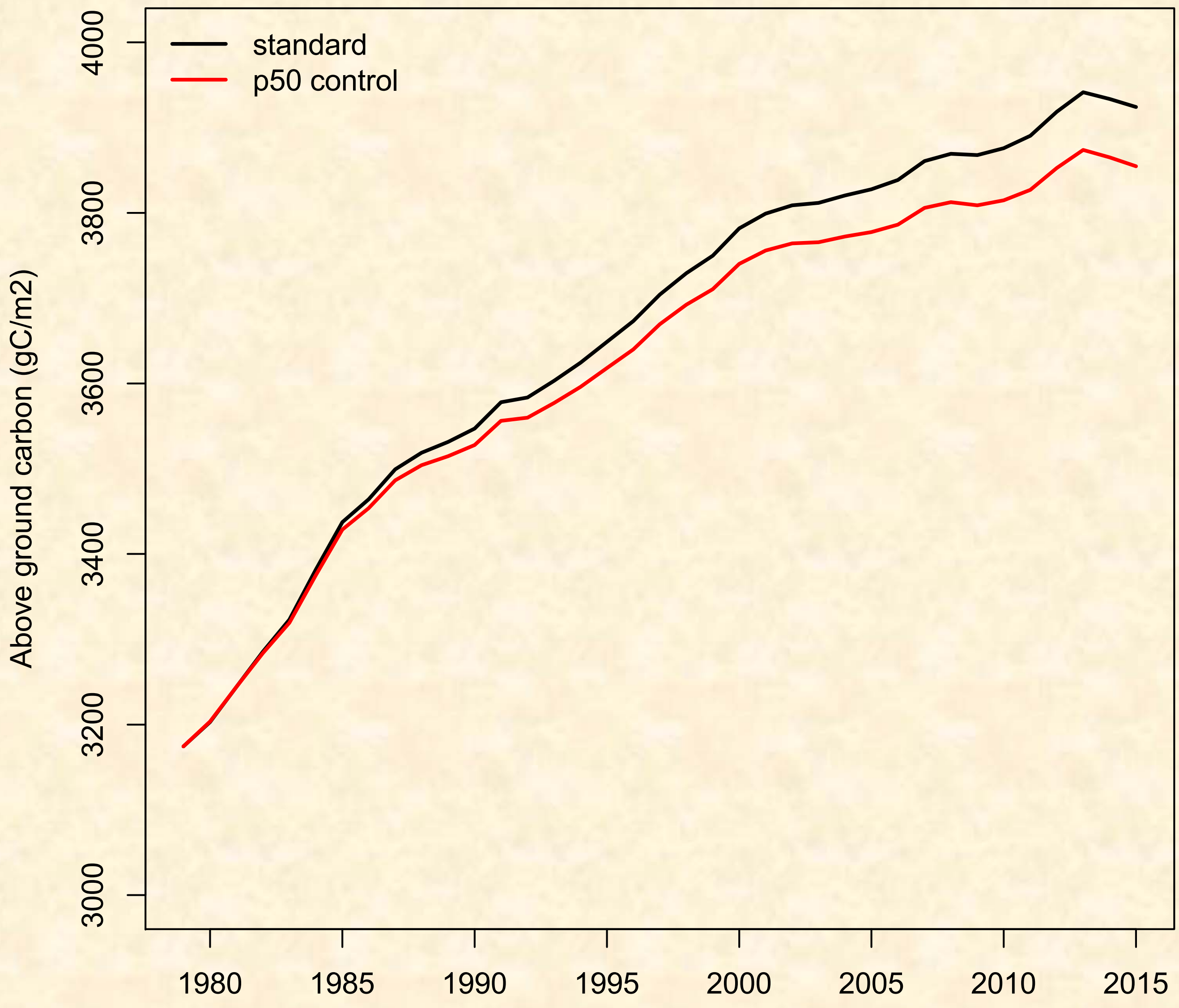
w_i = wilting factor in each soil layer based on soil water potential

$$w_i = \begin{cases} \dfrac{\psi_c - \psi_i}{\psi_c - \psi_o}\left[\dfrac{\theta_{sat,i} - \theta_{ice,i}}{\theta_{sat,i}}\right] \le 1 & \text{for } T_i > T_f - 2 \text{ and } \theta_{liq,i} > 0 \\ 0 & \text{for } T_i \le T_f - 2 \text{ or } \theta_{liq,i} \le 0 \end{cases}$$

Ψ_i = current soil water matric potential
Ψ_o = soil water potential when stomata are open
Ψ_c = soil water potential when stomata are closed: PFT specific

➢ **Use P50 values for each PFT in place of standard Ψ_c in parameter file**

Effect of Applying P50 Constraints



2. Water Stress Control on Leaf Shed

➢ **Increase leaf shed rate when water stress is high**

Variables added to parameter file:

- PFT-specific p50 value (Mpa) defining water stress
- # days of water stress required to trigger leaf shed

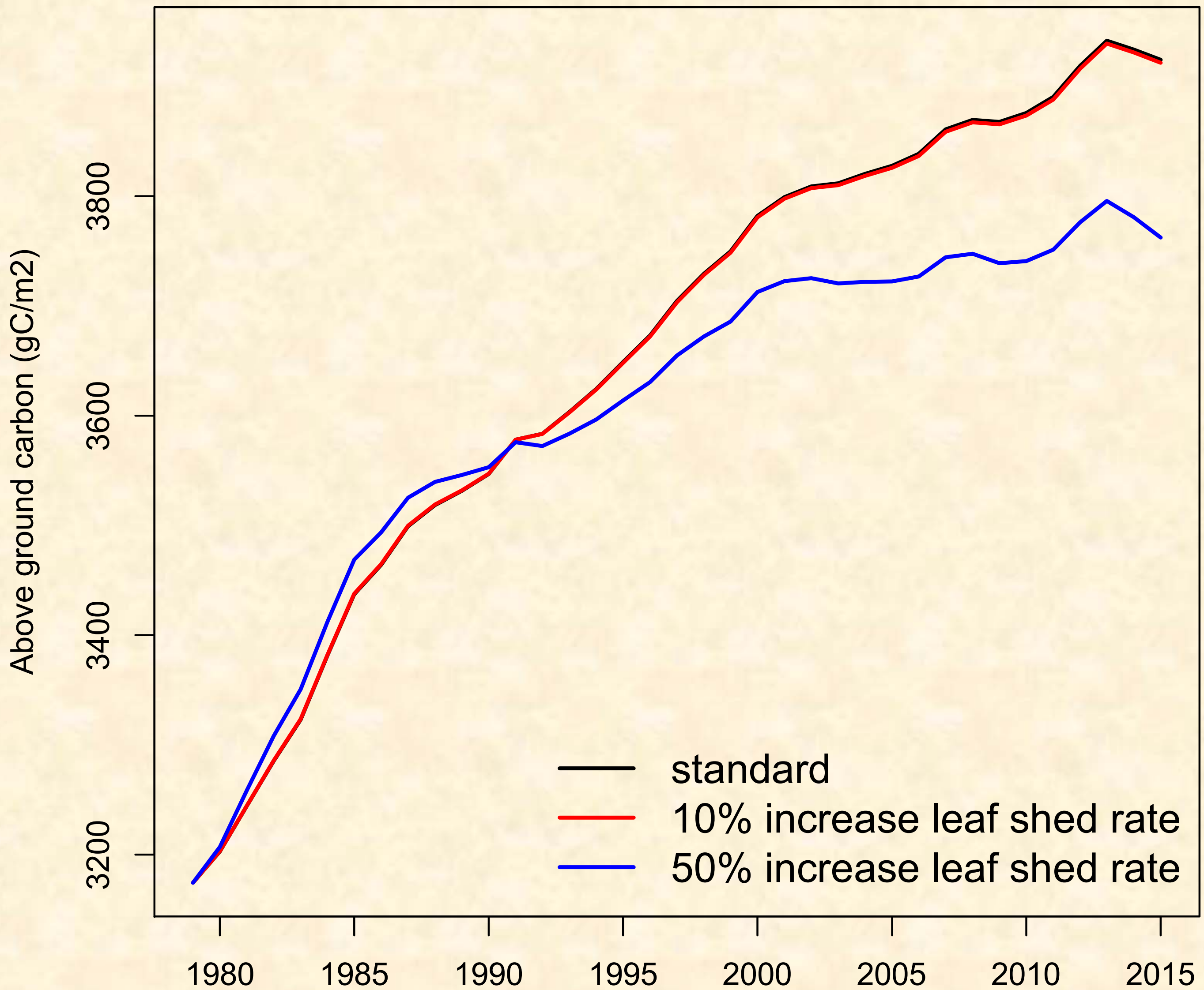
Code added to CNPhenologyMod.F90, CNEvergreenPhenology subroutine:

- shed_flag to trigger increased leaf fall rate when # days at critical soil psi reached
- hardwired leaf shed rate

Tunable parameters:

definition of water stress
length of stress period
leaf shed rate

Effects of Water Stress Control on Leaf Shed



3. Mortality Triggered by No Growth

➢ **Increase background mortality rate when allocation to growth is zero for a critical time period**

- Breshears et al. 2009: Pinyon mortality after 4-10 months of pre-dawn water potential below assimilation point

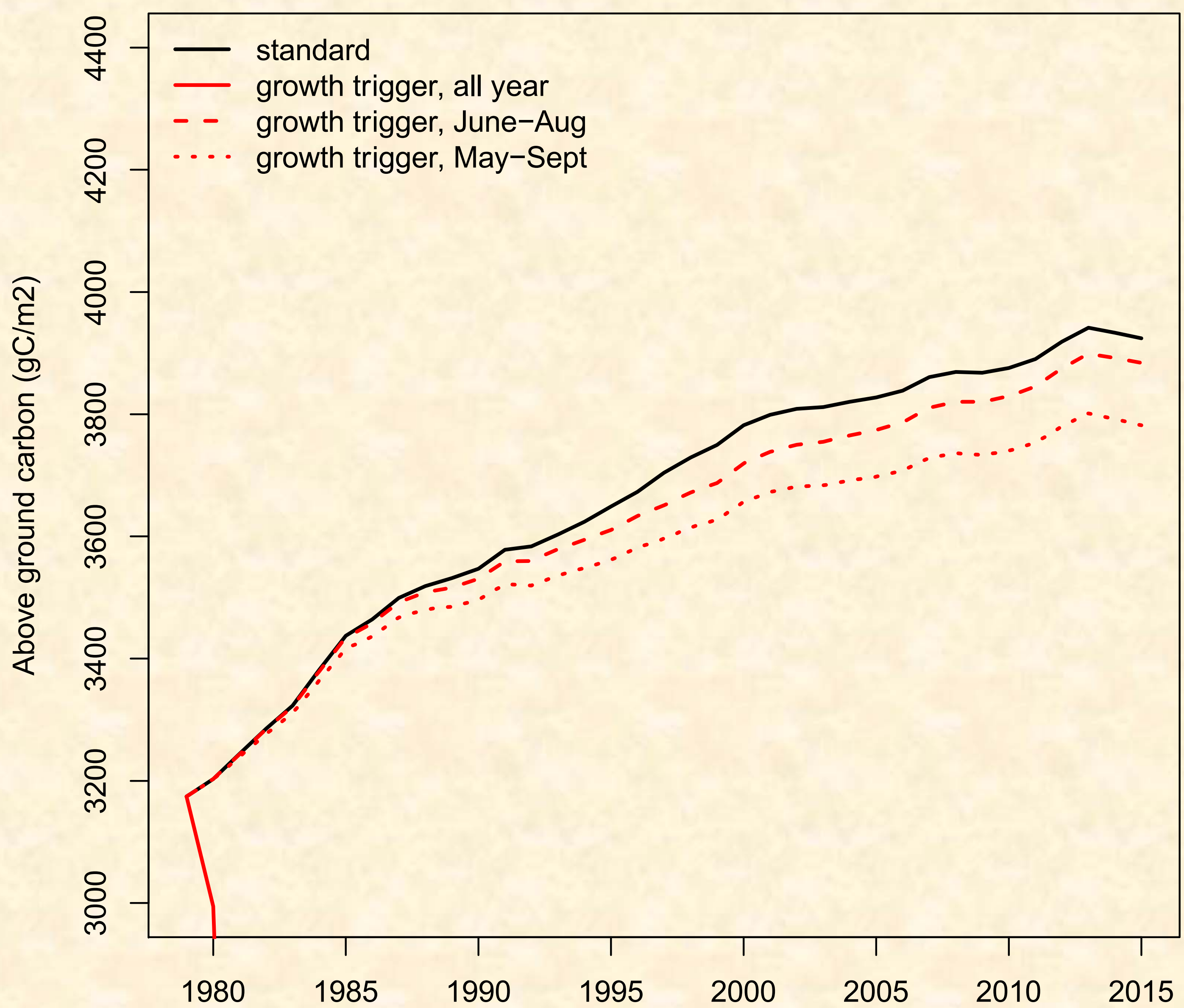
- Working with Adrian Das/Nate Stephenson to use their plot data in the Sierra Nevada to parameterize mortality rate given growth rate

Code added to CNGapMortality.F90

- index of days with no allocation to growth
- flag to trigger increased mortality rate
- mortality rate change hardwired

Potential: Select mortality rate from a constrained probability distribution, run CLM multiple times with same climate to produce a range of mortality estimates for a future time periods

Effects of Zero Growth-triggered Mortality



Tuning and Evaluation